

# Microfluidic Backbone and Components Using New Fabrication Capability for CBNP Applications



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**L**LNL has a long history of building instrumentation for the detection of biological pathogens. Within the past decade, the focus for these programs has been the detection of anthrax, plague, and other pathogens that may be released in a terrorist attack. The ability to detect low levels of pathogens in an extensive and cost-effective manner is difficult, and is likely to be the subject of on-going efforts for years to come. In addition to environmental monitoring for pathogens, other applications for the ability to test multiple of samples quickly and cost-effectively include verification of post-exposure restoration efforts. Following the clean-up activities associated with a biological attack on a building, as was seen in the Hart Building following the 9/11 anthrax release incidents, thousands of samples needed to be analyzed to ensure the destruction of the remaining spores.

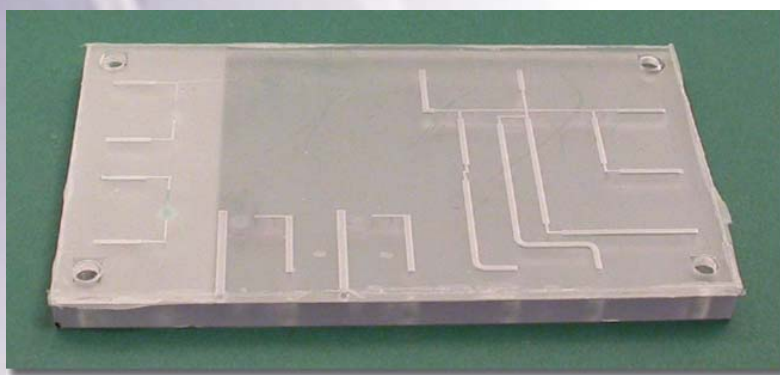


Figure 1. Plastic microfluidic system, showing the pattern of the flow channels.

## Project Goals

Our goal is to provide the capability of producing low-cost plastic-based microfluidic modules. In addition to this module, a latching actuator and a spring-actuated pump were built for use in portable instruments. Also, a module for dispensing a set of ten liquid chromatography samples simultaneously was built to demonstrate usefulness for a current application.

## Relevance to LLNL Mission

As an active participant in these and other programs for biological instruments for pathogen detection, LLNL needs the capability of producing low-cost plastic-based microfluidic modules similar to those published in the literature (see Related References).

## FY2004 Accomplishments and Results

The microfluidic module was built through the machining of acrylic. Figure 1 shows the pattern of the flow channels. The actuation mechanisms consist of pneumatically actuated membrane valves. A prototype was built to demonstrate the functions of metering, mixing, and pumping. The prototype initially used membrane material similar to the cited references. It was found through testing that the device suffered failings, consisting primarily of leaky valves and other seals, caused by normal chipping at the edges of the holes, scratches, bowing plates, and the excessive force required to create a gasket seal over a large, irregular surface.

Such difficulties were thought to limit the usefulness in cost-sensitive applications and where larger formats were needed.

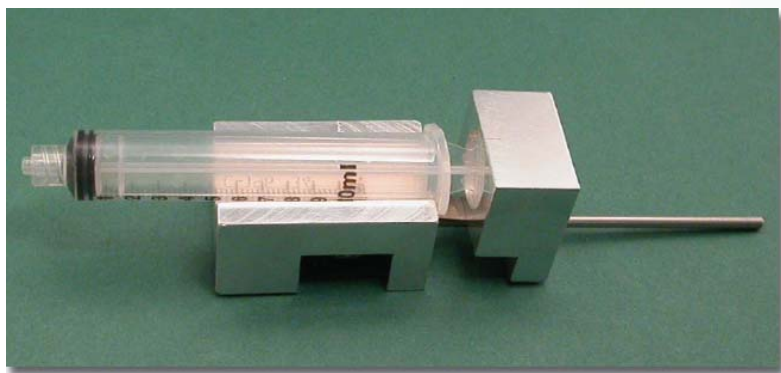


Figure 2. Spring-loaded pump for portable instrumentation.

Therefore, a new membrane scheme was implemented which used adhesive material to form the valve seats. When compressed, the thick membrane material was able to seal the valve. Peristaltic pumps were formed by depressing larger areas of adhesive-inhibited membrane material.

In portable bio-instrument applications, pneumatically actuated valves and pumps are inconvenient at best. The compressed air supply would have to be provided by either an air compressor or by transporting a small gas cylinder with each instrument built using this technology. To make this technology more appealing in cases where field-portable equipment is desirable, as may be the case for the first-responder community, a low-power latching valve was prototyped. The actuator mechanism is based on nickel-titanium shape memory alloy material. Two springs made of this alloy were set opposite each other to form the actuator, with a magnet providing the latching mechanism. This actuator was able to provide 1 N of force. A constant force pump (Fig. 2) was also demonstrated which could be used as a portable liquid source.

In addition to the basic fluidic module, a special fluidic module was built as a demonstration unit for a particular current application. The chosen application was a thin-layer chromatography unit to test numerous samples simultaneously for the presence of explosive material. In this case,

ten simultaneous samples of a specific sample volume were delivered to a chromatographic plate. The device needed to be extremely easy to operate and extremely low power. A module based on capillary action was built and tested. The module wicked in the desired sample volume and dispensed it similarly.

#### Related References

1. Anderson, R., X. Su, G. Bodgan, and J. Fenton, "A Miniature Integrated Device for Automated Multistep Genetic Assays," *Nucleic Acids Research*, **28**, (12), 2000.
2. Anderson, R., G. Bogdan, Z. Barniv, T. Dawes, J. Winkler, and K. Roy, "Microfluidic Biochemical Analysis System," *Proceeding of Transducers '97*, Chicago, Illinois, pp. 477-480, June 1997.